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Growth and distribution of 4TVW haddock

Croissance et répartition de l'aiglefin de 4TVW

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Abstract

The directed fishery for 4TVW haddock was closed in 1993 and has not been re-opened in spite of some rebuilding. Research survey data are used to examine the current numbers, growth and distribution of the haddock resource. Furthermore, a Test Fishery was planned for, and conducted in, 2004 to investigate the potential of 4TVW haddock for harvest if the minimum size, current 43 cm, were dropped to a smaller size to make more of the haddock available. Results show that both total and spawning biomass are near the long term average. However, this rebuilding is dominated by small fish as the growth rate has steadily fallen since the early 1980s.

Résumé

La pêche dirigée de l'aiglefin de 4TVW a été fermée en 1993 sans qu'il y ait reprise, malgré un certain rétablissement. Les données obtenues à l'aide du relevé scientifique sont utilisées pour examiner le nombre actuel de poissons, le taux de croissance et la répartition des ressources d'aiglefin. De plus, une pêche expérimentale a été prévue et réalisée en 2004, afin d'examiner le potentiel de pêche de l'aiglefin de 4TVW, si la taille minimale, actuellement à 43 cm, était abaissée en vue d'augmenter le nombre d'aiglefins exploitables. Les résultats montrent que la biomasse totale et la biomasse génitrice sont près de la moyenne à long terme. Toutefois, ce rétablissement est dominé par de petits poissons, car le taux de croissance est en baisse constante depuis le début des années 1980.

Introduction

This document is intended to provide biological advice relevant to the 4VW haddock stock and its potential for harvest. Two specific objectives were identified by the Maritime RAP office:

> In support of potential changes in management measures in 2005/06, report on recent trends in body growth and recruitment of 4TVW haddock
>
> Consider a report from the Groundfish Enterprise Allocation Committee (GEAC) on their 2004/05 Trial Fishery

Regarding growth, most of this analysis will be based on research survey data, and where appropriate the abundance indices will be corrected for the selectivity of the research gear using coefficients (q's) from an unpublished SPA. Similarly, recruitment trends will be estimated directly from the RV data.

Industry (GEAC) proposed a survey which had a number of objectives:

1. evaluate the separator panel,
2. evaluate retention characteristics of different mesh sizes on haddock and cod,
3. evaluate day/night effects,
4. collect haddock growth/maturity samples (length frequencies, full morphologies & otoliths).

The principal underlying question was whether a commercially viable haddock fishery was possible without significant cod bycatch. Observers were aboard to sample the catch and their data is used in the following analysis. Although a report from industry was anticipated, none was forthcoming.

The first leg of the GEAC survey was conducted in March 2004 and was monitored by the Observer Program and the data from their system is summarized below. A second trip had been planned but was never performed.

The most significant change to this resource over the period of research survey data, 1970 to present, has been the apparent change in growth. Over this period the otoliths have been read by several readers and the otoliths have been prepared for reading in different ways. A careful analysis and re-aging have been conducted to assure the reliability of these data. Appendix A summarizes these studies which concludes that the size at age data are comparative over the 35 year period and are reliable.

For reference, a summary of the catch history for this stock is given in Table 1.

Methods

The research survey data were extracted as standard data products from the Maritime Science Virtual Data Center (VDC). Specifically, they are numbers, length and weight at age as well as the geographic data concerning recent (2000-2004) summer surveys. Although a different survey vessel was used in 2004, this should not significantly affect the location or growth data. No inferences are being drawn on the abundance from the 2004 data, so this last point in the time series is only included for completeness and for qualitative comparison.

The abundance data were "q-corrected" using estimates of the survey gear's efficiency (q) from an SPA based on formulations from recent assessments (Mohn and Simon, 2002).

Results

Figure 1 shows the survey–based biomass (q corrected) for both the total (BTot) and spawning stock (SSB) estimates. Maturities for the SSB are time varying and are from Frank et al. (2001), with the most recent values extended to 2004. Although both growth and maturity have changed over the 35 years of survey data, the slightly lower age of maturity is not as serious as the depressed growth rate as a factor in the SSB. The recruitment is indicated by the number of 1 and 2 year olds in the summer survey. The very strong 1999 year-class is clearly seen as well as the resultant impact on total biomass. Since the 1999 year-class, recruitment has been unexceptional.

The question of growth is addressed by Figures 2 and 3. Figure 2 shows the weights at age for ages 2-7. Especially in the older ages, a reduction is weight at age is seen in the early 1980s and then a further slow erosion since that time. The corresponding lengths at age are shown in Figure 3; for reference, the 43 cm line is shown.

Information on haddock and cod distributions similar to Figures 4 and 5, were presented to the industry before the Test Fishery and these suggested that the periphery of the haddock box (See Figure 6) would be the areas of most probable success. However, Figure 6 shows the actual position of the sets and the total catches at each. Table 2 has more detail of the catch composition. The proportion of cod in these sets is higher than would be appropriate for any fishery in the near future. Figure 7 shows the location and catch of haddock which are shown in kilograms.

Conclusions

Size at age, and hence growth, significant decreased in the early 1980s and has not recovered since that time. The great majority of the stock is currently under the legal size of 43 cm. Although the biomass, or the spawning stock biomass, are comparable to the long term (since 1970) mean, the population is now dominated by small fish.

The Test Fishery did not meet its stated objectives. The logic behind the choice of trawling locations is not obvious. Furthermore, no information has been forthcoming as to why they

were chosen. The question of successfully harvesting haddock without significant impact on cod (or potentially other species yet to be designated) awaits a properly conducted test fishery.

Bibliography

Frank, K.T., R.K. Mohn and J.E. Simon. 2001. Assessment of the status of Div. 4TVW haddock: 2000. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/100.

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Table 1. Summary of landings from 4TVW haddock.

	Landings, t							
Year	1970-79	1980-89	1990-99	2000	2001	2002	2003	2004 *
TAC	1,333	12,970	2200					
Total	5,023	11,254	2200	71	107	113	35	25

*landings as of October 2004

Table 2. Observed catch from Industry Trial Fishery (kg)

Cod	12
Haddock	16
Silver hake	2
Pollock	6
Redfish	1015
Halibut	4
Plaice	2830
Witch	10
Wolffish	3
Herring	5
Thorny skate	179
Winter skate	38
Dogfish	5
Scorpion	381
Lumpfish	78

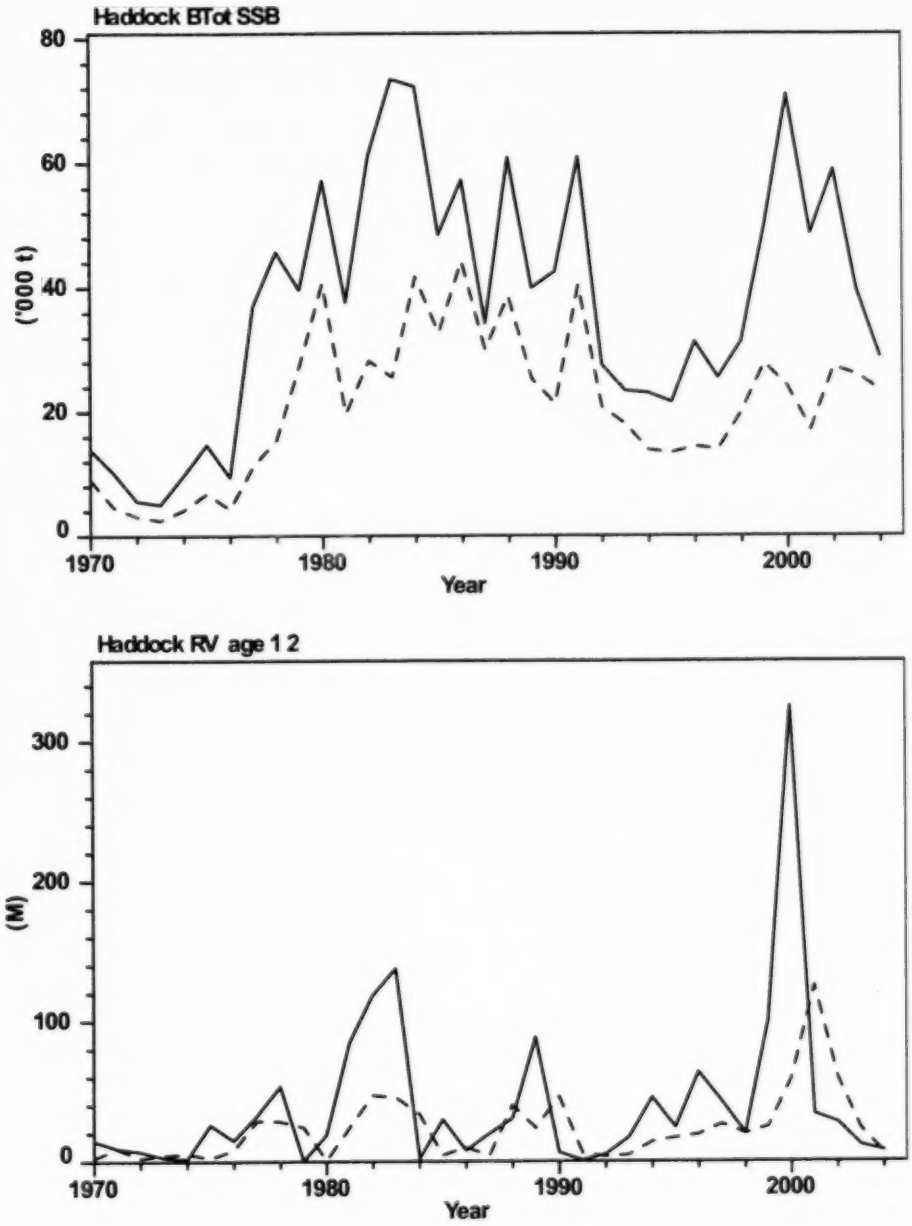


Figure 1. Haddock biomass and recruitment from summer survey data. The upper panel is total biomass (solid line) and spawning stock biomass (dashed). The estimates have been q corrected. Recruitment (lower panel) is inferred from the abundance of 1 (solid line) and 2 year olds (dashed).

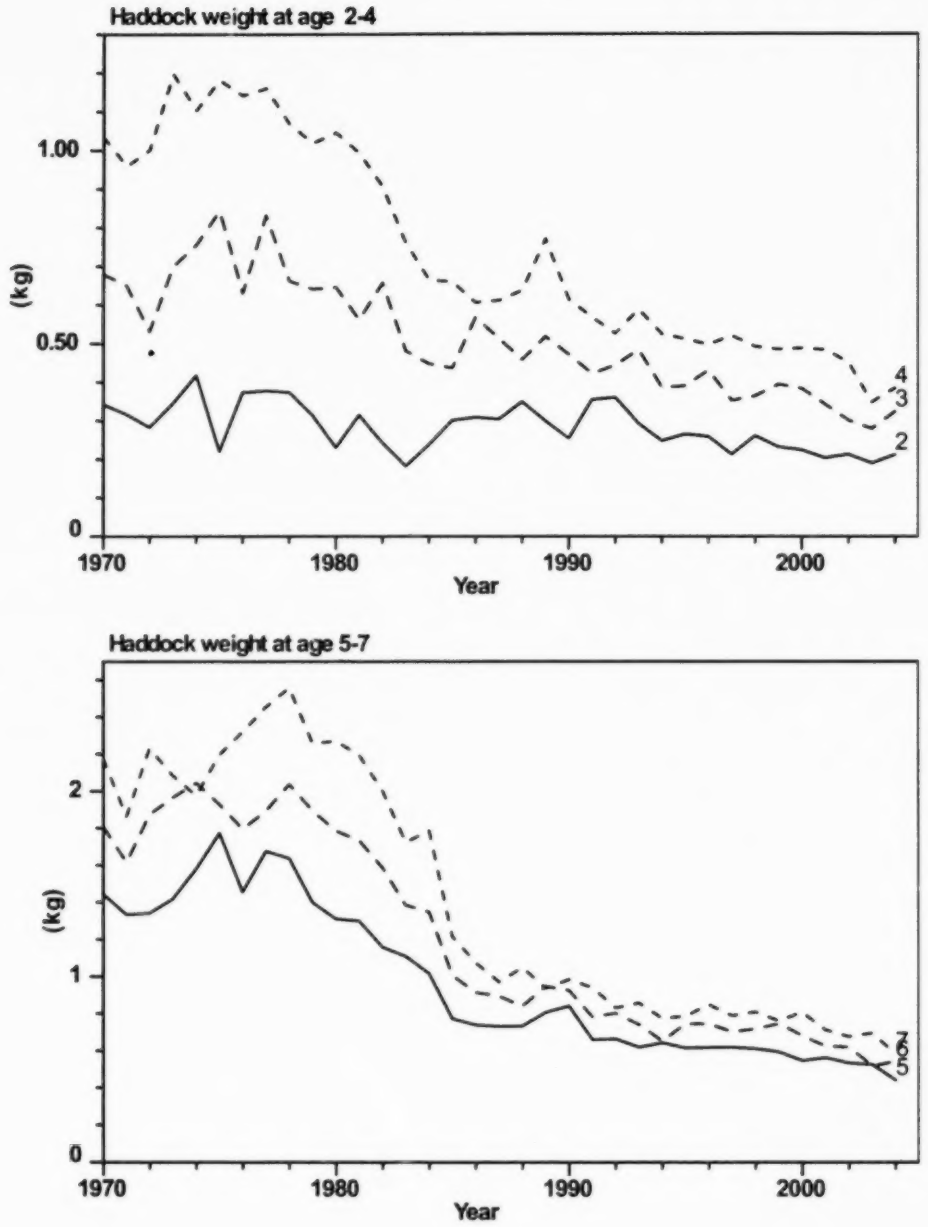


Figure 2. Haddock weight at age for ages 2-4 (upper panel) and ages 5-7 (lower) from the summer RV series.

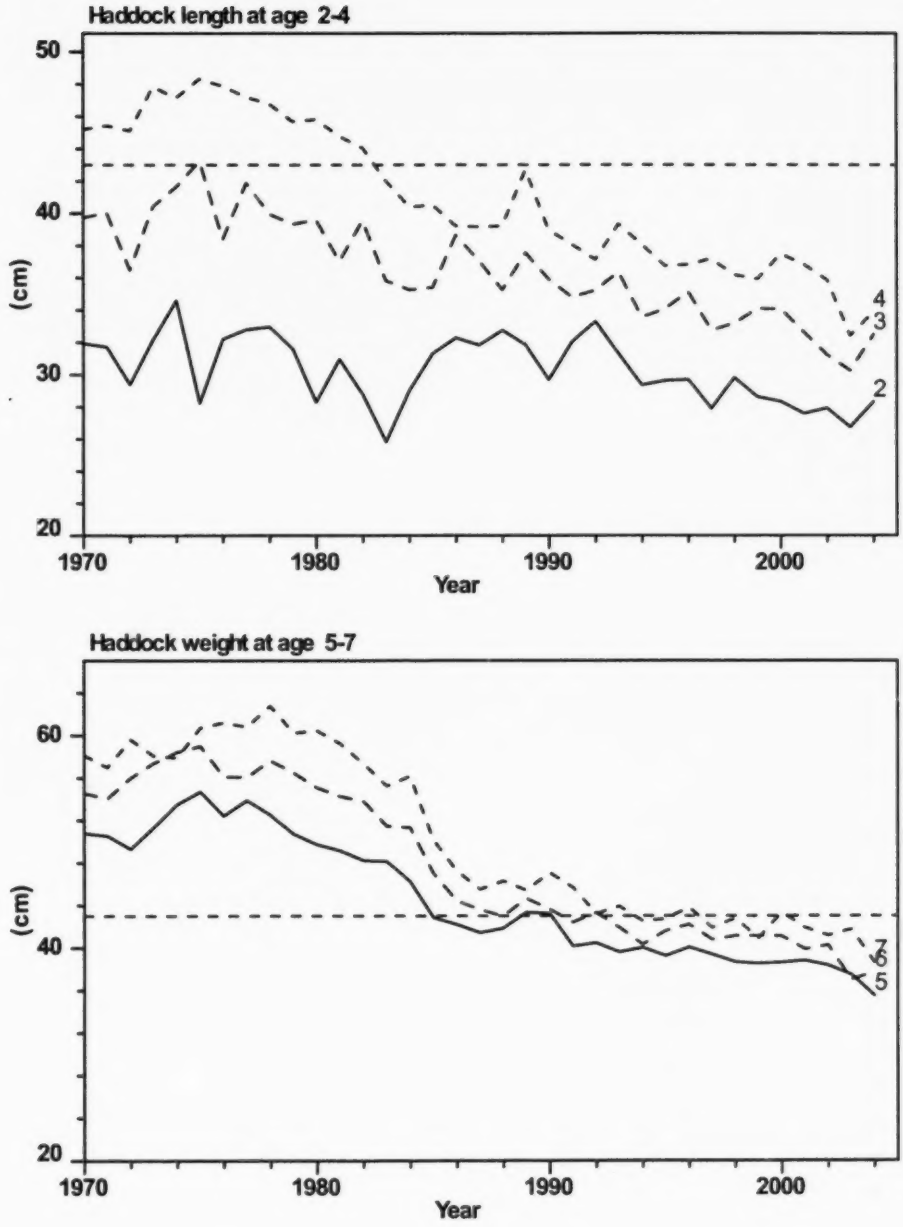


Figure 3. Haddock length at age for ages 2-4 (upper panel) and ages 5-7 (lower) from the summer RV series. The line at 43 cm represents the legal size limit.

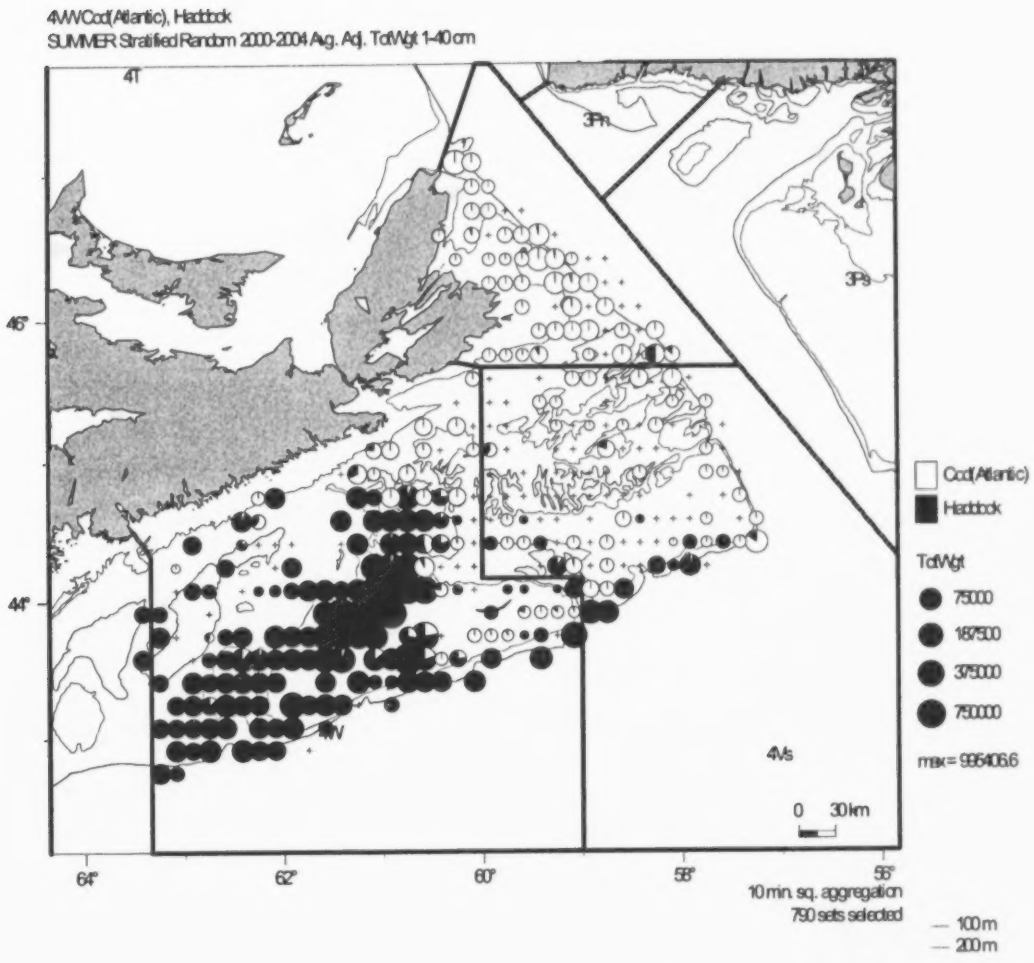


Figure 4. Distribution of small (< 41 cm) haddock and cod for the period 2000-2004.

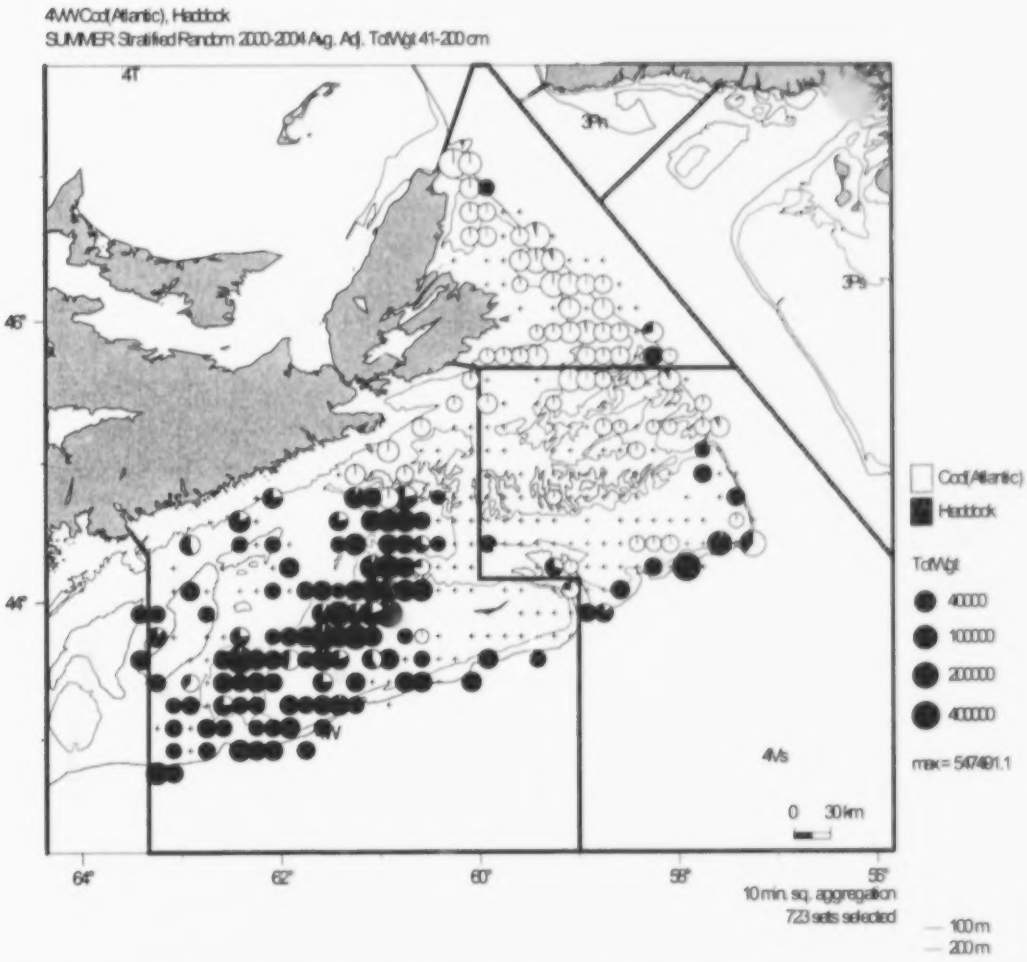


Figure 5. Distribution of large (>41 cm) haddock and cod for the period 2000-2004.

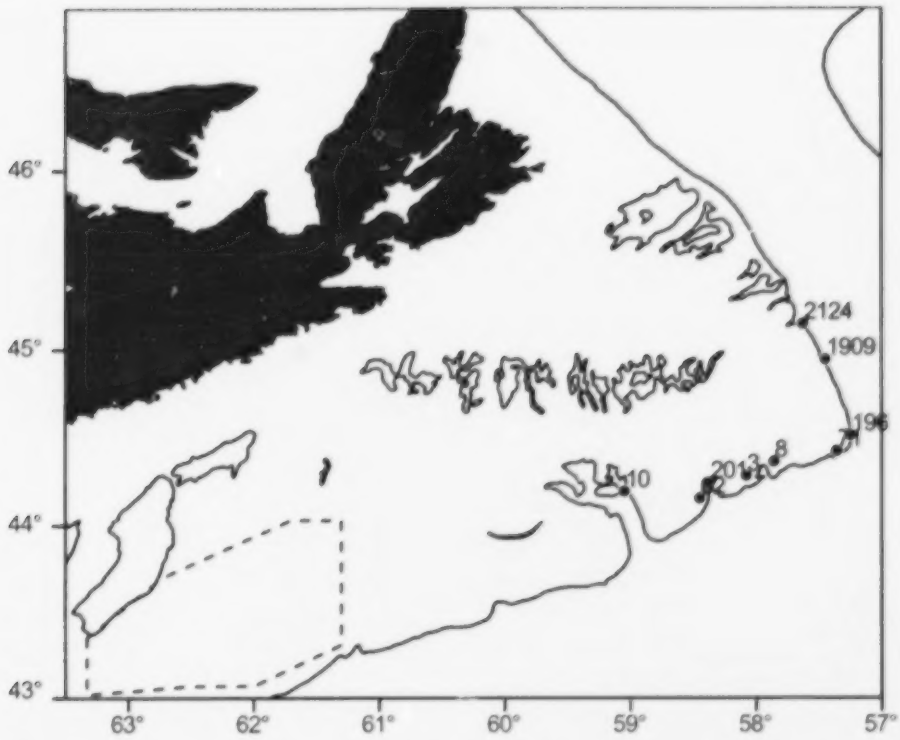


Figure 6. Total catches (kg) in 2004 Haddock Test Fishery are given at the site of each set. The dashed line denotes the haddock box.

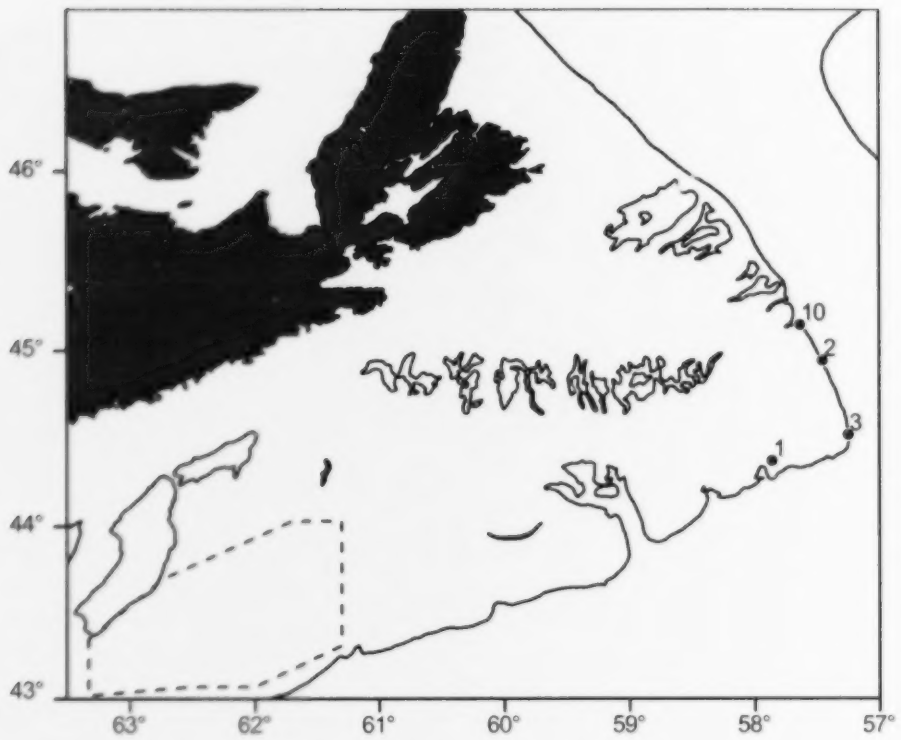


Figure 7. Haddock catches (kg) in 2004 Haddock Test Fishery are given at the site of each set. The dashed line denotes the haddock box.

Appendix A. Age validation studies of 4VW Haddock

The 1996 (Frank et al, 1997) and 2000 (Frank et al., 2001) stock assessments documented a problem that had developed in the ageing of 4VW haddock in the 1980's and early 1990's. Those assessments detailed some of the work that was used to address the problem but further documentation became necessary due to questions arising from differences in growth seen in the preparation of data for this assessment.

The new mean lengths at age calculated for the 1996 assessment suggested that growth prior to 1983 had been substantially higher than since 1985. A major 'step' in growth between 1984 and 1985 was noted resulting in a reduction in the mean lengths at age for some older ages of up to10cm (Frank et al, 1997). This step coincided with the change in aging technique from cracked to sectioned otoliths and the change in agers over the time period. The 4VW haddock stock had a single ager, Ager 1, from 1970- 1982 using the cracked otolith method (Table A1). In 1983, Ager 2 began aging the summer RV survey using the cracked otolith method. In 1985, the methodology was changed to sectioning otoliths that had been embedded in resin. When the sectioning method was first considered, tests were run to compare with the cracked method. These showed an acceptable percent agreement between the methods, and the change in methodology was implemented.. Ager 2 aged this stock until 1993, when the responsibility was transferred to Ager 3 and Ager 4. Due to the problems noted in the 1997 and 2001 assessments (Frank et al, 1997, Frank et al. 2001), the 4VW haddock summer RV survey and commercial sampling ages, from 1985-1993, were removed from the database and replaced by the ages generated by Agers3 and 4 (Table A1).

The commercial and survey otoliths from 1985 to present have been aged primarily by Ager 3. The ageing duty for this stock has been shared with a secondary ager, Ager 4 who acted as the primary ager in some of those years. Ager 4 was the primary otolith reader for the 1986, 1989, 1991 and 1995 summer RV surveys and the 1989 and 1990 commercial samples. Ager 3 aged the remainder of the summer RV surveys and the commercial samples since 1985. Each ager has been tested against each other and against the reference collection to ensure accuracy.

Given the major step in the mean length at age coincident with the changes in agers and methodology, a trial was conducted by Ager 3 to compare the cracked vs. sectioning methods. In the fall of 1997, 222 pairs of otoliths from that year's Sentinel Survey were prepared for ageing using the two methods. The first otolith of the pair was cracked and set in plasticine as per discussions with Ager 2. Initially both sides of the otolith were ground flat on a 2 stage grindstone and aged. While aging these fish it was noted that when an area of an otolith had not been ground, it appeared to be clearer than the ground area. Therefore for the last half of the test only one side of the cracked otolith was ground and the other side was left untouched. In all cases a soap/water mixture was applied to the otolith to enhance the clarity. The second otolith of the pair was embedded in resin and sectioned using the new methodology.

A comparison of the two methods revealed that the percentage of unaged fish (9.4%: 21/222) was higher using the cracked method than when sectioned(3.6% 8/222) Whether this was due to inexperience by Ager 3 using this method or the condition of the otoliths is unknown. When the 193 otoliths pairs were considered no consistent bias was evident between the two methods but the CV was high 8.9% (Figure A1).When a subset of the otoliths (95) using only the revised no grinding method was considered the CV was an acceptable 5.87% with no bias. The conclusion at the time was that the two methods did not give significantly different results.

In 1998 a sub-sample of 292 cracked otoliths from the 1982 summer RV survey was recovered, cleaned and remounted in plasticene. No surface preparation other than cleaning with soap and water due to mould on the otoliths was done prior to aging. The appearance of the otoliths was different than freshly cracked otoliths. Ager 2 and another ager experienced in aging cracked otoliths mentioned that the otoliths tended to become whiter and lose definition over time. The first annulus and edges were especially difficult to interpret. The percentage of unaged fish (12.3% 36/292) was similar to the 1997 test. The original ages from Ager 1 were compared with the ages generated by Ager 3. The CV of 7.6% was high but deemed acceptable at the time (Figure A2). No bias was evident in ages 0-6, but a bias of about half a year was evident by age 7 and increased from ages 8 to 11. The mean lengths at age were calculated for the two agers. No significant differences are evident from ages 0-6. At ages 7 and 8 Ager1's fish were approximately 5cm longer than Ager's 3. This difference was less than the 10cm step noted in the 1996 assessment, but we could not distinguish between ager or method differences.

For the 2000 4VW haddock assessment, otoliths were aged from the 1995 to 2000 4VsW Sentinel Surveys to provide an additional abundance index for tuning the VPA. For the 2002 assessment, it was decided to continue to age the Sentinel Survey as well as age otoliths from the spring (1979-84) and 4VWCod RV surveys (1986-present) in 4VW (called March survey in remainder of text).

The March survey otoliths from 1979- 1982 had been cracked and aged originally by Ager 1. A single cracked otolith from each pair were glued together, embedded in resin, sectioned, and then aged by Ager 3. The March survey otoliths from 1983,1984,1987,1988 and 1990 had already been embedded in resin and aged by Ager 2. These otoliths were simply re-aged by Ager 3.

Yearly CV and bias plots were generated by comparing the original ages from the survey with those re-aged by Ager 3. The results showed that the CV's in 1979 was 4.3% with no bias (Figure A3).The 1982 results showed a very low CV(3.9%) with potentially a slight bias to underage older fish (8+) (Figure A4). The 1983 and 1984 results has CV's which although not high (5.2 and 7.7% respectively) indicated an increasing bias to underage fish 5 years and older (Figures A5, A6). The 1987 and 1990 tests showed a high CV (>12%) with a strong bias towards under-aging fish greater than 5 years old. This observation was similar to that observed in the summer RV survey in 4VW.

Based on these results it was decided that given the good agreement between Agers 1 and 3 in the 1979 and 1982 surveys that there was no need to adjust the ages from 1979 to 1982 March surveys.

Given the biases at the older ages in the sectioned otoliths from the March 1983-1990 surveys the decision was made to remove these ages from the database. The ages generated by Ager 3 for this survey were entered on the system, a new catch-at-age matrix constructed for the March survey and then used to tune the VPA.

Summary

The re-ageing of the cracked otoliths using the sectioning method did not show significant differences in the results and therefore we can conclude that the data from 1970-1982 is comparable with the data from 1985 to present. However, the summer RV survey ageing from 1983 and 1984 should be used with caution. The implications of the 3 aging studies described above, is that the change in growth seen in the mid-1980s is not an artifact of the change in method or agers.

The initial examination of the Sentinel surveys otoliths suggested that the differences in methodology did not produce significantly different ages. Indirectly this provided evidence that the change in methodology was not the major cause in the change in growth observed in this stock and that the 1970 – 1982 catch at age could be compared to the catch at age from 1985 to present. Given the materials available at the time the 1983 and 1984 surveys were not examined. The 1998 study was a direct examination of 1982 summer RV survey otoliths and came to a similar conclusion although a bias was noted to underage fish greater than 8 years old. This bias might have been due to the condition of the otoliths used in the study.

The 2003 study was much more extensive and although it used otoliths from a different seasonal survey provided the best evidence that ages derived from otoliths aged prior to 1983 using the cracked method were comparable to the sectioned method used since 1985. The observed drift appeared to have begun in 1983. The use of percent agreement between two samples probably masked a problem at the older age groups given the small samples sizes at those ages. This study suggests that since the 1983 and 1984 haddock ages from the March RV survey had problems, then it is likely as they were read by the same reader that the 1983 and 1984 summer RV surveys will have a similar problem. In addition, since the 4X haddock otoliths were aged by essentially the same agers as in 4VW at the same time then it is likely that the same problems will applied there as well.

Appendix A Bibliography

Frank, K.T., R.K. Mohn and J.E. Simon. 1997. Assessment of 4TVW haddock in 1996. DFO Can. Sci. Advis. Sec. Res. Doc. 97/107, 90p.

Frank, K.T., R.K. Mohn and J.E. Simon. 2001. Assessment of 4TVW haddock in 2000. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/100, 96p.

Table A1. Summary of haddock ages on the DFO database since 1970 from the summer and March RV surveys in Div. 4VW.

Year	Summer RV Survey Otoliths Mission	Ager 1	Ager 2	Ager 3	Ager 4	Method	March Survey Otoliths Mission	Ager 1	Ager 2	Ager 3****	Method
1970	ATC1970175, ATC1970176	768				cracked					
1971	ATC1971188, ATC1971189	512				cracked					
1972	ATC1972200, ATC1972201	459				cracked					
1973	ATC1973212, ATC1973213	293				cracked					
1974	ATC1974225, ATC1974226	338				cracked					
1975	ATC1975236, ATC1975237	531				cracked					
1976	ATC1976250, ATC1976251	561				cracked					
1977	ATC1977265, ATC1977266	659				cracked					
1978	ATC1978279, ATC1978280	691				cracked					
1979	ATC1979292, ATC1979293	749				cracked	HAM1979013, HAM1979014	645**			cracked
1980	ATC1980306, ATC1980307	880				cracked	HAM1980033, HAM1980034	635			cracked
1981	ATC1981321, ATC1981322	972				cracked	HAM1981048, HAM1981049	885			cracked
1982	HAM1982081, HAM1982082	1124*				cracked	HAM1982071, HAM1982072	1026**			cracked
1983	NED1983012, NED1983013		1134			cracked	HAM1983094, HAM1983095		354***	553	sectioned
1984	NED1984031, NED1984032		1126			cracked	NED1984024, NED1984025		366***	333	sectioned
1985	NED1985048, NED1985049			1060		sectioned	NED1985041 (FEP)				no otoliths
1986	NED1986065, NED1986066				529	sectioned	NED1986060				no otoliths
1987	NED1987085, NED1987086, NED1987087			465		sectioned	NED1987077, NED1987078		697***	323	sectioned
1988	NED1988105, NED1988106			564		sectioned	NED1988098		319***	clarity problem	sectioned
1989	NED1989123, NED1989124				650	sectioned	NED1989117			384	sectioned
1990	NED1990139, NED1990140			523		sectioned	NED1990134		436***	449	sectioned
1991	NED1991154, HAM1991231				490	sectioned	NED1991149			399	sectioned
1992	NED1992173, NED1992174			305		sectioned	NED1992166			204	sectioned
1993	NED1993189, NED1993190			444		sectioned	NED1993182			142	sectioned
1994	NED1994221, NED1994222			761		sectioned	NED1994201			395	sectioned
1995	NED1995139, NED1995140				660	sectioned	NED1995217			285	sectioned
1996	NED1996226, NED1996227			614		sectioned	NED1996238(incomplete survey)			171	sectioned
1997	NED1997246, NED1997247			777		sectioned	NED1997255			438	sectioned
1998	NED1998726, NED1998734			650		sectioned	Survey cancelled (some otoliths from maturity study available)				
1999	NED1999925, NED1999929			738		sectioned	NED1999872			457	sectioned
2000	NED2000426, NED2000431			757		sectioned	NED2000966			464	sectioned
2001	NED2001032, NED2001037			721		sectioned	NED2001004			398	sectioned
2002	NED2002037, NED2002040			763		sectioned	NED2002003			388	sectioned
2003	NED2003036, NED2003042			607		sectioned	NED2004003			374	sectioned
2004	TEL2004529, TEL2004530			599		sectioned	Survey cancelled				

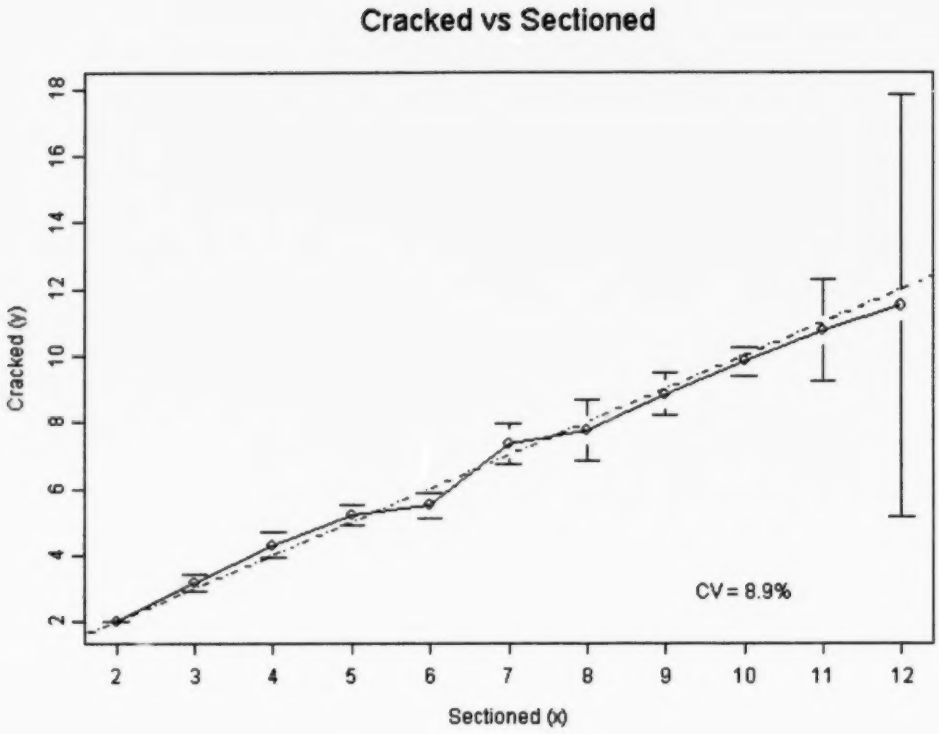
Note: See text for further explanation of footnotes below.

* Subsample tested against Ager 3. Ager1 ages (1970-1982) remain on database.

** Subsamples from 1979,1982 tested against Ager 3. Ager 1 ages (1979-1982) remain on database

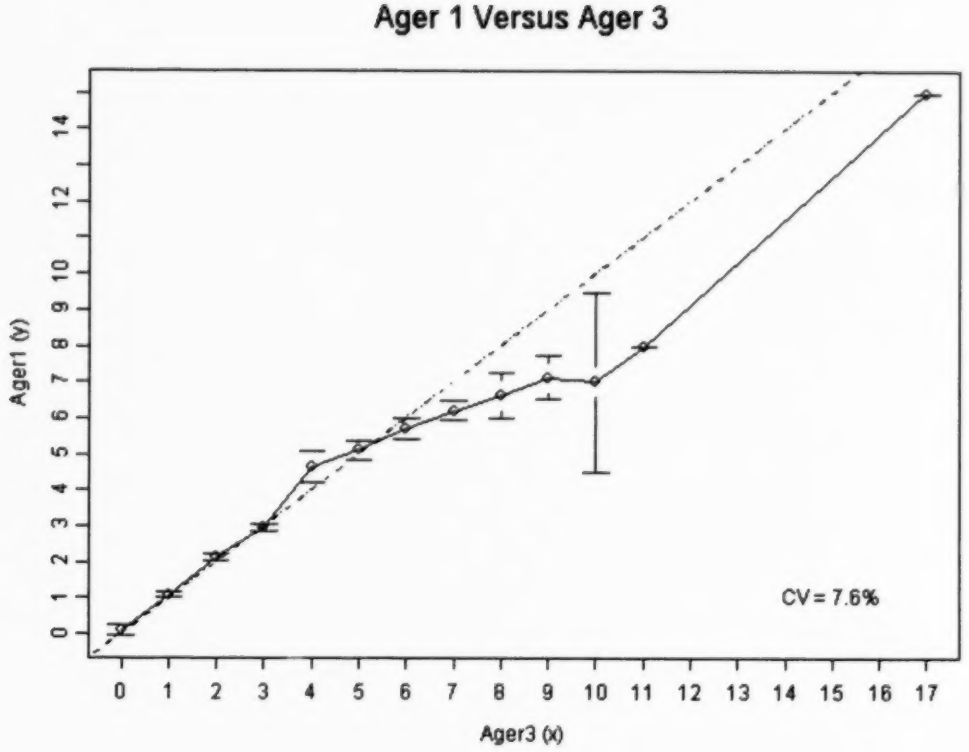
*** Subsamples from 1983,1984,1987 and 1990 tested against Ager 3. Ages removed from database (1983-1990).

**** Ages on database, 1983-present



	Cracked (y)											
Sectioned (x)	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
2	1	0	0	0	0	0	0	0	0	0	0	1
3	1	14	5	0	0	0	0	0	0	0	0	20
4	1	3	13	8	3	0	0	0	0	0	0	28
5	0	1	5	16	11	2	0	0	0	0	0	35
6	0	1	4	14	9	6	1	0	0	0	0	35
7	0	0	0	0	2	8	2	1	1	0	0	14
8	0	0	1	1	1	3	4	4	2	0	0	16
9	0	0	1	0	1	1	3	10	7	1	0	24
10	0	0	0	0	0	0	1	4	9	3	0	17
11	0	0	0	0	0	0	0	0	2	1	1	4
12	0	0	0	0	0	0	0	0	0	1	1	2
Total	3	19	29	39	27	20	11	19	21	6	2	196

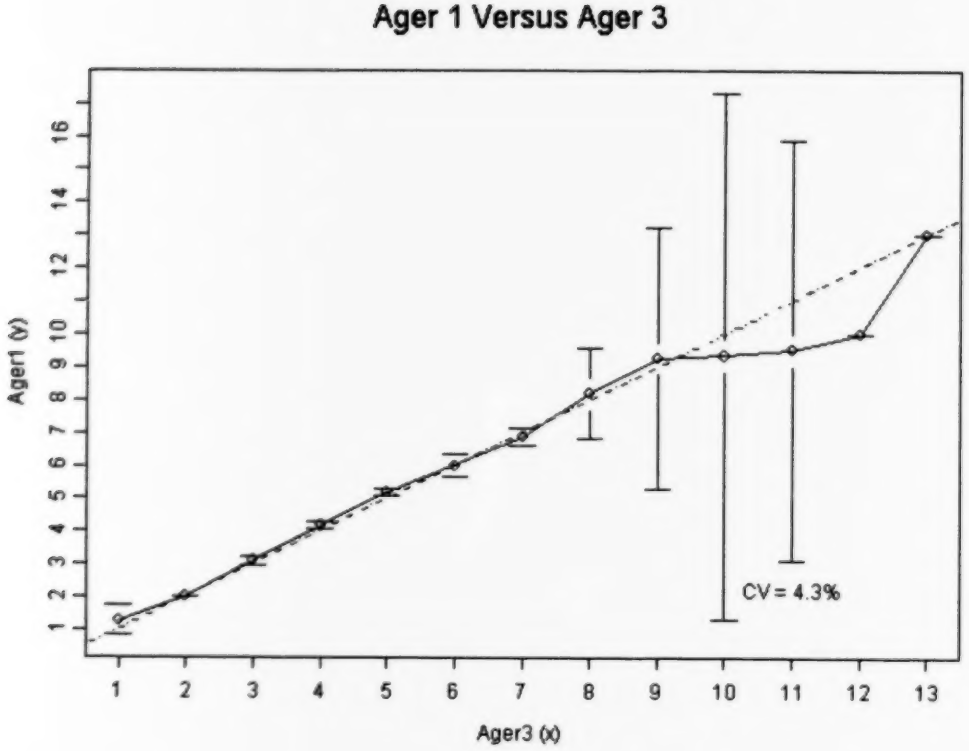
Figure A1. Diagnostic bias plot and table of differences between cracked and sectioned haddock otolith pairs from the 1997 4VW Sentinel Survey.



1982

	Ager1 (y)											
Ager3 (x)	0	1	2	3	4	5	6	7	8	9	15	Total
0	16	2	0	0	0	0	0	0	0	0	0	18
1	0	38	4	0	0	0	0	0	0	0	0	42
2	0	0	36	5	0	0	0	0	0	0	0	41
3	0	0	3	36	1	0	0	0	0	0	0	40
4	0	0	0	0	3	5	0	0	0	0	0	8
5	0	0	0	1	2	18	7	0	0	0	0	28
6	0	0	0	0	1	8	13	3	0	0	0	25
7	0	0	0	0	0	3	13	8	0	0	0	24
8	0	0	0	0	1	1	5	6	2	1	0	16
9	0	0	0	0	0	0	2	4	3	0	0	9
10	0	0	0	0	0	0	1	1	1	0	0	3
11	0	0	0	0	0	0	0	0	1	0	0	1
17	0	0	0	0	0	0	0	0	0	0	1	1
Total	16	40	43	42	8	35	41	22	7	1	1	256

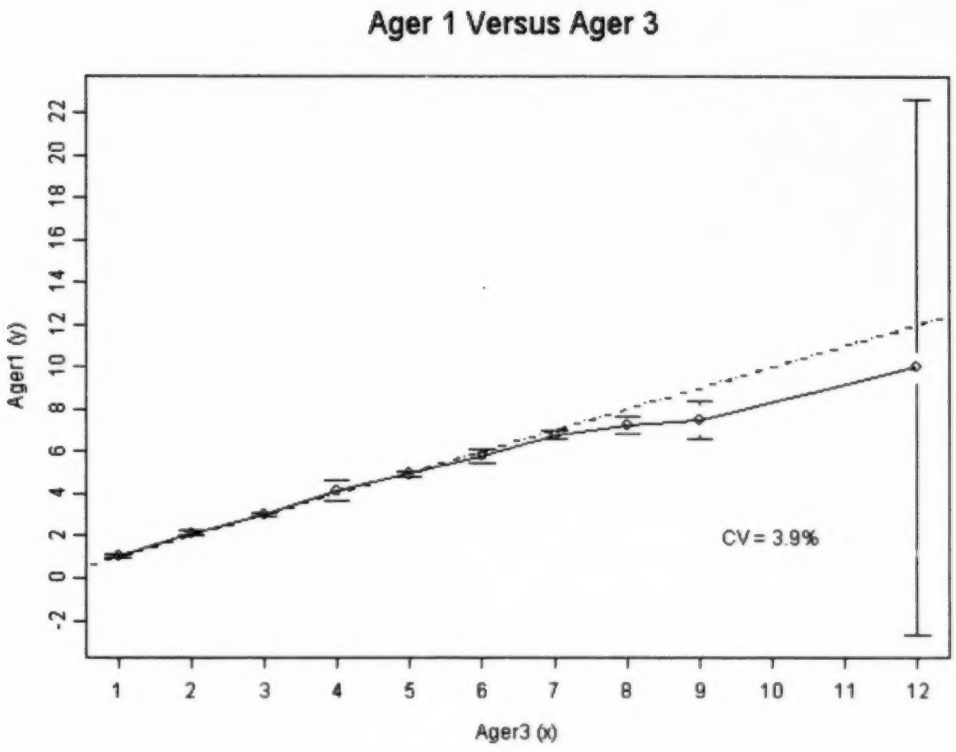
Figure A2. Diagnostic bias plot and table of differences between cracked haddock otoliths aged by Ager 1 in 1982 and Ager 3 in 1998 from the 1982 summer RV Survey.



1979

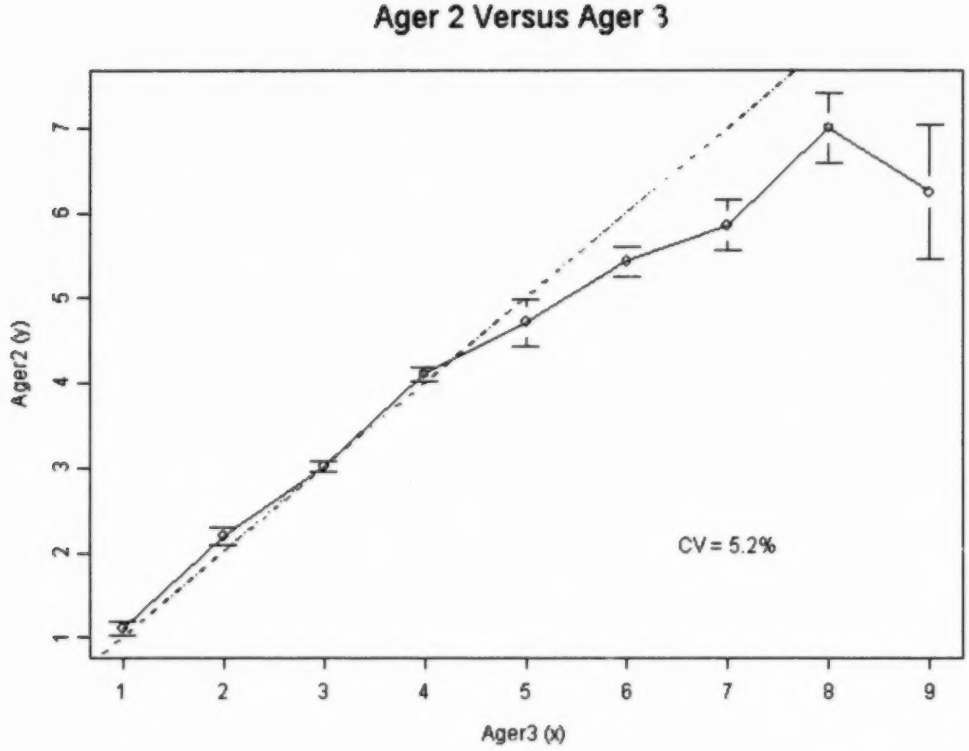
Ager3 (x)	Ager1 (y) 1	2	3	4	5	6	7	8	9	10	13	Total
1	5	2	0	0	0	0	0	0	0	0	0	7
2	0	82	1	0	0	0	0	0	0	0	0	83
3	0	6	55	14	0	0	0	0	0	0	0	75
4	0	0	2	60	14	1	0	0	0	0	0	77
5	0	0	0	6	74	21	2	0	0	0	0	103
6	0	0	0	0	5	9	5	0	0	0	0	19
7	0	0	0	0	3	4	26	4	1	0	0	38
8	0	0	0	0	1	0	3	4	1	1	1	11
9	0	0	0	0	0	0	0	3	0	0	1	4
10	0	0	0	0	0	0	1	1	0	0	1	3
11	0	0	0	0	0	0	0	0	1	1	0	2
12	0	0	0	0	0	0	0	0	0	1	0	1
13	0	0	0	0	0	0	0	0	0	0	1	1
Total	5	90	58	80	97	35	37	12	3	3	4	424

Figure A3. Diagnostic bias plots and table of differences between Ager 1 and Ager 3 from the 1979 spring RV survey of 4VW haddock otoliths.



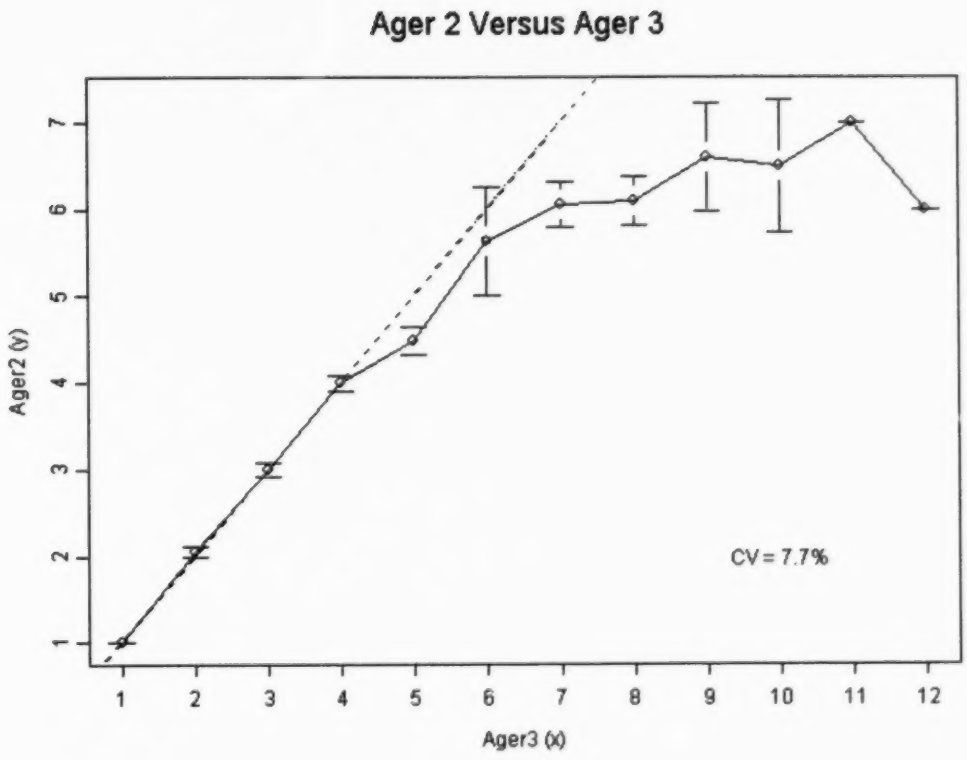
	Ager1 (y)										
Ager3 (x)	1	2	3	4	5	6	7	8	9	11	Total
1	45	3	0	0	0	0	0	0	0	0	48
2	0	59	11	0	0	0	0	0	0	0	70
3	0	4	58	4	0	0	0	0	0	0	66
4	0	0	2	5	4	0	0	0	0	0	11
5	0	0	0	6	55	2	0	0	0	0	63
6	0	0	0	0	9	11	2	1	0	0	23
7	0	0	0	0	0	4	16	0	0	0	20
8	0	0	0	0	0	1	6	4	0	0	11
9	0	0	0	0	0	0	4	1	1	0	6
12	0	0	0	0	0	0	0	0	1	1	2
Total	45	66	71	15	68	18	28	6	2	1	320

Figure A4. Diagnostic bias plots and table of differences between Ager 1and Ager 3 from the 1982 spring RV survey of 4VW haddock otoliths.



	Ager2 (y)									
Ager 3 (x)	1	2	3	4	5	6	7	8	9	Total
1	51	6	0	0	0	0	0	0	0	57
2	0	49	12	0	0	0	0	0	0	61
3	0	1	61	2	0	0	0	0	0	64
4	0	0	0	46	5	0	0	0	0	51
5	0	0	0	4	10	0	0	0	0	14
6	0	0	0	0	25	16	1	0	0	42
7	0	0	0	0	6	12	3	0	0	21
8	0	0	0	0	0	3	10	1	1	15
9	0	0	0	0	0	3	1	0	0	4
Total	51	56	73	52	46	34	15	1	1	329

Figure A5. Diagnostic bias plots and table of differences between Ager 2 and Ager 3 from the 1983 spring RV survey of 4VW haddock otoliths.



	Ager2 (y)									
Ager 3 (x)	1	2	3	4	5	6	7	8	9	Total
1	22	0	0	0	0	0	0	0	0	22
2	0	52	3	0	0	0	0	0	0	55
3	0	2	44	2	0	0	0	0	0	48
4	0	0	3	48	3	0	0	0	0	54
5	0	0	0	25	20	1	0	0	0	46
6	0	0	0	1	4	4	2	0	0	11
7	0	0	0	0	6	23	5	0	1	35
8	0	0	0	0	7	13	10	0	0	30
9	0	0	0	0	2	6	4	2	1	15
10	0	0	0	0	2	3	3	2	0	10
11	0	0	0	0	0	0	2	0	0	2
12	0	0	0	0	0	1	0	0	0	1
Total	22	54	50	76	44	51	26	4	2	329

Figure A6. Diagnostic bias plots and table of differences between Ager 2 and Ager 3 from the 1984 spring RV survey of 4VW haddock otoliths.